INSTRUMENT
INSTRUCTIONS

INSTRUMENT
CENTER

SENSITIVE RESEARCH
INSTRUMENT CORPORATION
NEW ROCHELLE, N.Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

Instrument No. 805901

INSTRUCTION MANUAL

FOR THE

OPERATING AND MAINTENANCE

OF OUR

SELF CHECKING

STANDARD A.C.-D.C. VOLT-AMP-MILLIAMMETER

MODEL **THACH**

COMBINATION 1-X and COMBINATION 2-X

SINGLE & DOUBLE THERMO COUPLE DESIGNS

Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N.Y

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

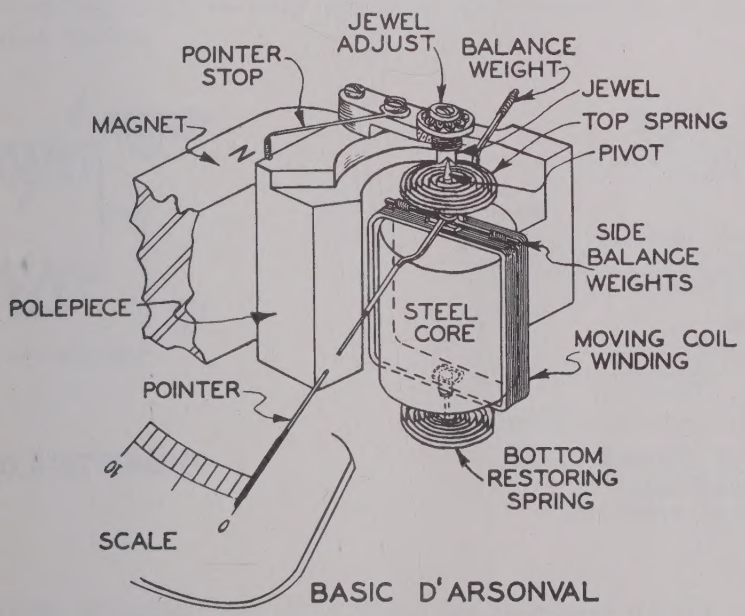
ELECTRICAL MEASURING INSTRUMENTS

D. C. CURRENT MEASUREMENTS

Almost all electrical measurements involve the detection or measurement of an electric current. An electric current can be measured by means of one or more of its physical effects;

1. Heating Effect
2. Chemical Effect
3. Magnetic Effect

Using the magnetic effect caused by a current flow, we can devise an accurate means of measurement. The oldest design of such a device is known as the D'Arsonval Moving Coil System. An elementary sketch of which is shown below.



BASIC D'ARSONVAL MOVING COIL ASSEMBLY

Its operation depends on the force exerted on a current carrying conductor shaped in a coil which is capable of rotation in the field of a permanent magnet.

When a D.C. current flows through this rotatable coil, it creates a field which interacts with the permanent magnet field and produces a torque.

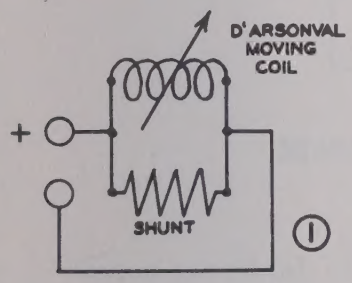
This torque is proportional to the magnet strength, the current in the moving coil, and the number and area of the moving coil turns. The torque produced rotates the mobing coil until its spiral springs are wound up sufficiently to produce an equal and opposite torque. When this point is reached the pointer deflection will be directly proportional to the current which produced it.

Essentially, a D'Arsonval moving coil, which in Sensitive Research Instrument is reactangular in shape, has a steel or diamond pivot at each end which turns in spring mounted jewel bearings.

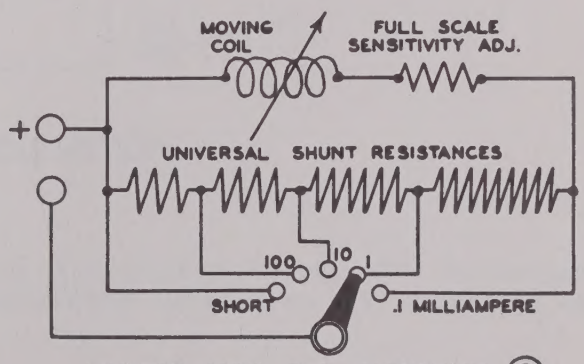
The D.C. current enters and leaves the moving coil usually through spirally constructed phosphor bronze springs which are coiled in opposite directions. These springs also provide the controlling force which opposes the deflecting force created by the current flow through the moving coil turns.

The accuracy of such an assembly to date is superior to any other known type of current deflected mechanism for electrical measuring instruments.

As such a moving coil system will not usually carry over 30 milliamperes without heating errors, we shunt any additional current past the moving coil. By means of calculated and accurately constructed shunts, either single or in a multiple system, we can measure D.C. currents of large magnitude even though the moving coil is only carrying and measuring 30 milliamperes or less. (See circuits below)



SHUNTED INSTRUMENT



MULTIRANGE D.C. CURRENT ② INSTRUMENT
.1-1-10-100 MILLIAMPERES

SENSITIVE RESEARCH has developed and improved during the past 31 years the basic D'Arsonval moving coil system so that today we use it even in our 1/20 of 1% LABORATORY STANDARD D.C. Instruments.

When properly constructed, a D'Arsonval moving coil system will accurately measure very minute D.C. currents as low as .01 of one microampere (.00000001 ampere) and indicate this small magnitude of current by a pointer on an indicating scale drawn in divisions-deflection. This extremely high sensitivity is unusual in portable indicating D.C. Instruments.

D. C. VOLTAGE MEASUREMENTS

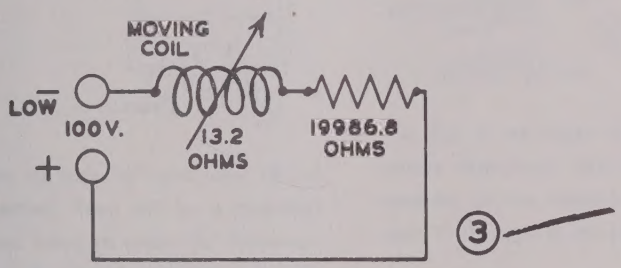
The D'Arsonval moving coil system movement is a current measuring device, but by following a principle of ohms law we can use this current measuring movement to measure D.C. voltage.

FOR EXAMPLE

Assume we wish to measure 100 volts direct current. Also assume that we have a D'Arsonval movement that deflects full scale for 5 milliamperes with a resistance of 13.2 ohms. By Ohms Law, 100 volts across a circuit of 20000 ohms will have a current flow of 5 milliamperes (.005 amperes) by:

$$\frac{100 \text{ Volts}}{.005} = 20000 \text{ Ohms}$$

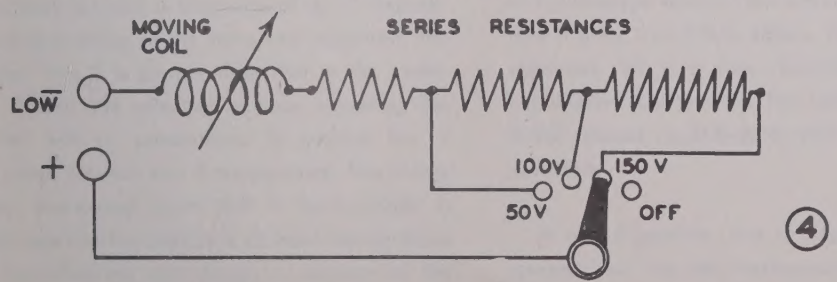
If we place our D'Arsonval moving coil (13.2 ohms) in series with a 19986.8 ohms resistor to equal 20000 ohms;



SIMPLE
SINGLE RANGE VOLTMETER
100 VOLTS

Then a potential of 100 D.C. volts will cause a current of 5 milliamperes (.005 ampere). Moving coil pointer deflection can then be calibrated and marked on the scale as 100 volts.

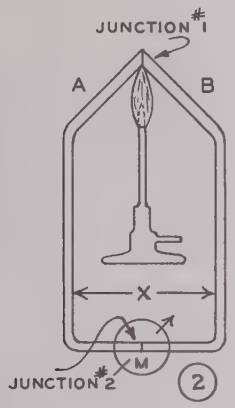
Using the ohms law formula and suitable calculated resistances, we can readily construct multirange D.C. Voltmeters.



MULTIRANGE D.C. VOLTMETER
50-100-150 VOLTS

THERMO-COUPLE INSTRUMENTS

The operation of all types of thermocouple instruments depends on the fundamental fact that there is produced at the junction of two dissimilar metals, a small D.C. voltage proportional to the temperature of that junction.

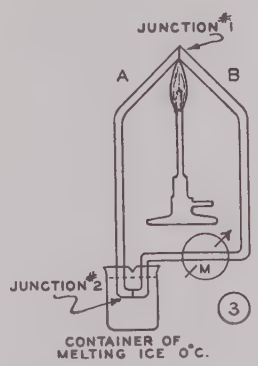


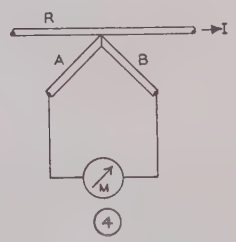
In Fig. 1, if the junction of wire "A" and wire "B" of two different metals is heated, there will be a potential developed between the two wires, at point "X." However, if we are to measure that developed potential, we ordinarily have to connect an instrument as shown at "M" in Fig. 2. In this case, we of course have a complete circuit, and current will flow because of the potential developed.

Please notice that in completing the circuit, we have of necessity created another junction between wires "A" and "B" where they meet in the instrument at junction No. 2.

Junction No. 2 also produces an EMF between the wires at point "X," and due to the polarity, this potential tends to counteract the EMF from junction No. 1. Inasmuch as the EMF from each junction is proportional to its temperature (both junctions being of the same two materials), the EMF of junction No. 1 is greater than that of the cooler junction No. 2 and the effective voltage operating the instrument "M" will be proportional to junction No. 1 temperature minus junction No. 2 temperature. This brings out the often overlooked point that a thermocouple is *never a single* junction but always is at least two junctions and hence its indications are always a measure of the *difference of two temperatures,* rather than the direct measurement of a temperature.

If we make a circuit as shown in Fig. 3 and make the colder of the two junctions stay at some definite point such as that of melting ice, then the thermocouple, when calibrated, gives actual direct readings.





In Fig. 4, we begin to approach a commercial thermocouple instrument. We have a wire "R" of resistance material, so that when it heats due to the passage of current "I" through it, the junction of "A" and "B" is heated.

The temperature of the "AB" junction will be proportional to the temperature reached by wire "R" due to the passage of current "I" plus the ambient temperature at which it started. The temperature of the cold junction at the instrument will be ambient temperature, and so we find that the EMF read by the instrument is proportional to ambient plus I^2R heat (the hot junction temperature) minus ambient (the cold Junction) temperature. Thus, we see that we can calibrate the meter "M" in terms of current "I."

The temperature of the heating wire "R" is proportional to the average value of the current squared (I^2) and therefore it gives true R.M.S. values. Assuming that the heating resistance "R" is a pure resistance with no inductive or capacitative components, the instrument will read in true R.M.S. values regardless of any waveform or frequency variation.

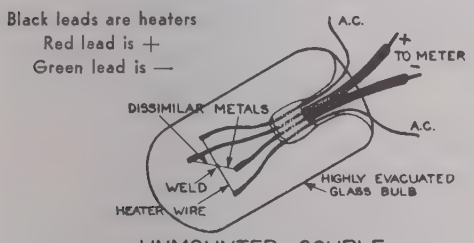
In actual practice, due to slight residual reactive components, our vacuum thermocouples can be operated at several megacycles for the thermocouple only, used outside the instrument.

When, however, it is mounted inside an instrument with its associated wiring, such an instrument will be within 1% accuracy up to approximately a megacycle (single range instruments).

In the case of a shunted thermocouple current instrument, such as a switch controlled multirange design, this frequency is still further lowered to about 20 K.C. (See figure 5).

Having now made a device which can operate a D.C. instrument (millivoltmeter) in proportion to the RMS values of current of any waveform or frequency flowing through the heater, the next major step is to increase the sensitivity. The overall sensitivity of the thermocouple depends on the temperature reached for a given current flow through the heating wire "R."

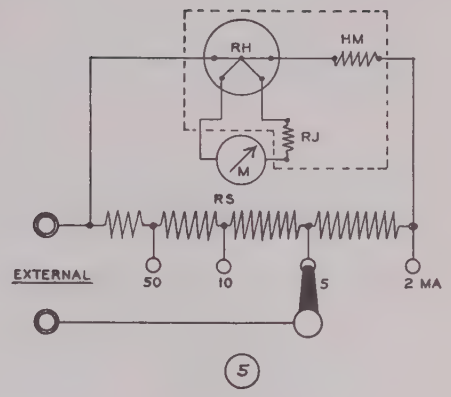
The current flow through a fixed resistance value will produce a definite number of calories per minute. However, the lead wires and the junction wires will carry some of the heat away, both of which are conduction losses. Some of the heat will be lost by direct radiation from the heater. Still more of this heat will be lost by conduction through the surrounding air and by convection currents of this air. This loss can be eliminated by placing the thermocouple in a small evacuated bulb resulting in the well known VACUUM THERMOCOUPLE.



UNMOUNTED COUPLE

In actual practice there are a few other points that have to be considered. Fig. 5 shows the thermocouple circuit of a typical multirange milliammeter with the portion inside the dotted rectangle being the actual thermocouple circuit. This is the portion available from the outside of the case with our "Replaceable Thermocouple" feature. See page

"HM" and "RJ" resistances bring the heater resistance and junction current up to standard values. Both will ordinarily be changed along with the thermocouple should it be accidentally burned out. The correct values can be obtained from us for any given instrument.



5

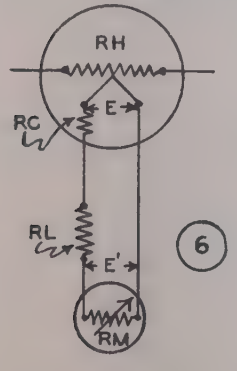
The resistance "RH" is to be measured at the current for full scale deflection of the millivoltmeter by measuring the voltage drop across the heater with a potentiometer while this current is flowing. This is NOT necessarily the full scale current of the instrument, but that portion of it which is to flow in the thermocouple heater circuit, usually about 75% of the full scale value of the most sensitive range in the case of shunted current instruments. This adding of resistance to the heater to bring it to some fixed value is necessary to match the balance of the resistance network for purposes of making instruments of identical characteristics. The resistance "RJ" is an added resistance in the junction circuit to take care of the individual variations in sensitivity of the thermocouples. "RJ" is furnished in the correct value with replacement couples for instruments with the "Replaceable Thermocouple" feature, or it is determined by comparison of full scale readings against a known standard for instruments not having this feature.

We have shown that the usual thermocouple instrument is made by using a thermal junction to read the temperature of a resistance carrying the current we wish to measure. The temperature of this resistance will vary with the watts dissipated, or I^2R. This temperature, being proportional to the square of the current flowing, makes the instrument give true RMS readings. This is very desirable, but it also gives rise to a poor overload characteristic. Doubling the current through the heater, gives four times the temperature; tripling the current, nine times the temperature; etc., so that a temperature that is sufficient to melt the heater is soon reached. This is why it is not advisable to overload the usual thermocouple instruments more than 100% unless protected by our "INSTRUMENT PROTECTION CIRCUIT" (See page

One common error in the selecting of instruments for use with thermocouples is in the use of the "open circuit millivolts" listing for the thermocouple. This rating is given on the basis of the open circuit voltage output of the thermal junction when the heater is carrying rated current. This is *not* to be taken as the range of a millivoltmeter to be used for full scale deflection, because normal types of millivoltmeters draw some current. In Fig. 6, a millivoltmeter with an internal resistance "RM," is connected to a vacuum thermocouple. The voltage "E" (open circuit millivolts listing) will not be the external voltage "E'" which actuates the meter because of the IR drops in the internal resistance of the junction circuit itself, the series resistance and in the instrument.

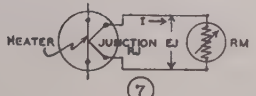
In thermocouples having heater currents from 1 milliampere to 1 ampere, the junction resistance varies from approximately 5 to 15 ohms. We therefore recommend for average measurements a 10-ohm, 200-microampere, 2-millivolt instrument (our code SMVPU) for use with any of these thermocouples. This has been a standard instrument with us for many years and has proved very successful for thermocouple use

It can be shown that we have the most efficient operation when the resistance of the millivoltmeter equals the resistance of the junction. For this condition we have maximum power transfer. Looking at the following circuit in Fig. 7 we have the following parameters.



6

R_J = Resistance of the junction itself
E_J = EMF developed by couple
I = Current flowing in the circuit
R_M = Millivoltmeter resistance
P_M = Power dissipated in millivoltmeter



7

$$I = \frac{E_J}{R_J + R_M}$$

$$P_M = I^2 R_M = \frac{E_J^2}{(R_J + R_M)^2} \times RM$$

Differentiating P_M with respect to R_M and setting the resultant equation equal to zero, we can solve for the value of RM which gives maximum power transfer.

$$\frac{dP_M}{dR_M} = [E_J]^2 \left(\frac{(R_J + R_M)^2 - 2R_M (R_J + R_M)}{(R_J + R_M)^4} \right) = 0$$

$$[E_J]^2 \left(\frac{(R_J + R_M)^2 - 2R_M (R_J + R_M)}{(R_J + R_M)^4} \right) = 0$$

$$(R_J + R_M)^2 - 2R_M (R_J + R_M) = 0$$

$$R_J^2 + 2R_M R_J + R_M^2 - 2R_M R_J - 2R_M^2 = 0$$

$$R_J^2 = R_M^2$$

$$R_J = R_M$$

For those of you who have some odd range millivoltmeters around the laboratory and still wish to use thermocouples in conjunction with them, we recommend the following formula for determining the most appropriate millivoltmeter, the best being the one which gives the largest value for RL.

$$R_L = \frac{E\, R_M}{E'} - (R_M + R_C)$$

E' = Instrument range in millivolts
E = Open circuit millivolt rating of couple
R_M = Instrument resistance
R_C = Junction resistance (not heater res.)
R_L = Lead resistance if long leads are used *plus* any additional series resistance to give an exact full scale deflection.

The exact value of R_L cannot always be correctly calculated due to the fact that different thermocouples may have slightly different outputs. In practice the correct value of R_L should therefore be determined roughly by the above formula and most precisely by experimenting with a variable resistance box in the junction circuit with a known standard current through the heater. The variable resistance box is then adjusted to give a full scale reading for this current. The higher value of R_L is desirable because of the higher total resistance in the junction circuit, thus making it less susceptible to extraneous thermal EMF's and to resistance changes in leads and wiring. The higher series resistance also lessens the period of the instrument to some extent which is extremely desirable in thermocouple instruments since it results in faster measurements.

[redacted] torque is proportional to the magnet strength, the current in the moving coil and the number and area of the moving coil turns. The torque produced rotates the moving coil until its spiral springs are wound up sufficiently to produce an equal and opposite torque. When this point is reached the pointer deflection will be directly proportional to the current which produced it.

Essentially a D'Arsonval moving coil which in Sensitive Research Instruments, is rectangular in shape has a steel or diamond pivot at each end which turns in spring mounted jewel bearings.

The D.C. current enters and leaves the moving coil usually through spirally constructed phosphor bronze springs which are coiled in opposite directions. These springs also provide the controlling force which opposes the deflecting force created by the current flow through the moving coil turns.

The accuracy of such an assembly to date is superior to any other known type of current deflected mechanism for electrical measuring instruments.

D. C. VOLTAGE MEASUREMENTS

The D'Arsonval moving coil system movement, is a current measuring device but by following a principle of ohms law we can use this current measuring movement to measure D. C. voltage or millivoltage.

FOR EXAMPLE:

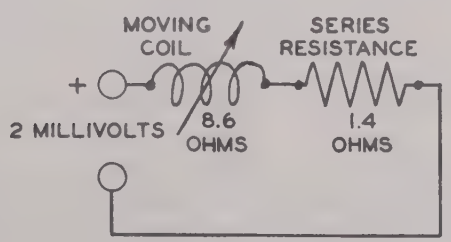
As written in preceeding pages the millivolt output of a vacuum thermocouple is best measured on a D. C. Microammeter of 200 microampere sensitivity, with a millivolt drop of 2 millivolts.

Using OHM'S LAW:

$$R = \frac{E}{I} = \frac{.002 \text{ Volts (2 Millivolts)}}{.0002 \text{ Amps. (200 Microamps.)}} = 10 \text{ Ohms}$$

Therefore, a 200 microampere instrument must be made to have a resistance of 10 ohms.

See circuit below.



SINGLE RANGE MILLIVOLTMETER

GENERAL INFORMATION

Upon receipt, your instrument should be carefully unpacked and examined for any visible external damage, i.e; split case, cracked glass, broken binding posts, etc. Place the instrument on a reasonably level bench. If the instrument has a wire shunting (across) the terminals, it should be removed. With the mechanical zero adjuster thumb knob, move the pointer both above and below the zero line of the scale. It should have sufficient travel to go a little beyond zero in each direction. Set the pointer exactly on zero while lightly tapping the instrument case with your fingers. The pointer will be correctly adjusted for zero when no reflection of the pointer's knife edge can be seen in the anti-parrallax mirror and the pointer is directly over and in line with the scale zero.

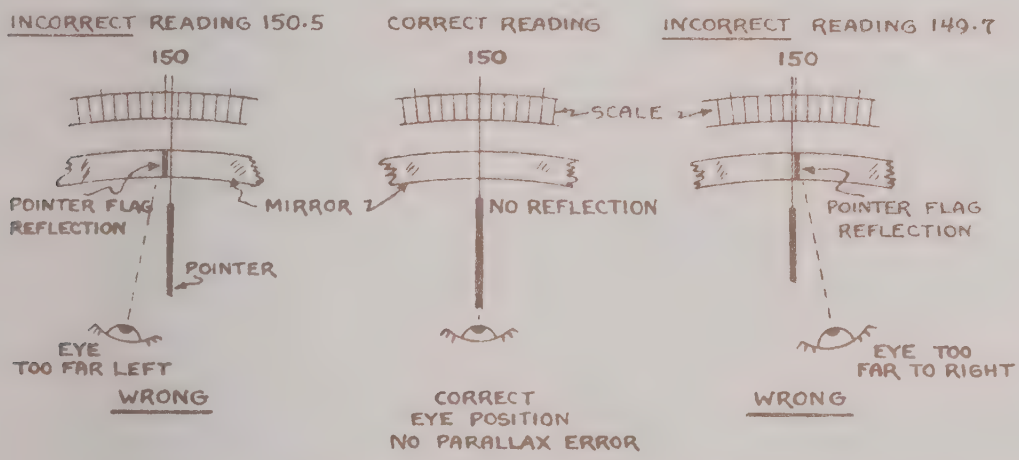


ILLUSTRATION OF THE ANTI-PARALLAX PRINCIPLE

The pointer indication should only be "read" when no reflection of its knife edge can be seen in the mirror below. This is only obtained when the eye is directly over the pointer. The drawings above illustrate the anti-parallax principle.

BALANCE TESTS FOR DIRECT CURRENT INSTRUMENTS

The general testing procedure for balance on all portable and panel instruments is the same, the difference being only in the degree of angle that the instrument is tipped from a horizontal position.

1. See that the pointer is set exactly on its zero position.

2. Now tip the instrument slowly up from the side farthest from you to an angular position as shown on the table below, and tap gently. The pointer should NOT move more than the amount shown on the table below.

3. Next, lay the instrument flat again and then tip it on its side, first left, then right, and tap gently.

In both of these procedures, the instrument should be within its balance specifications. In general, these specifications are as follows:

DIRECT CURRENT INSTRUMENTS

MODEL	ACCURACY	ANGLE FROM HORIZONTAL	BALANCE GUARANTEE
UPP PANEL	.5 of 1%	90°	.5 of 1%
UP PANEL	1%	90°	.5 of 1%
J,JW,S, UNIVERSITY PORTABLE	.5 of 1%	25°	.5 of 1%
C PORTABLE	.25 of 1%	25°	.25 of 1%
B LAB. STANDARD	.1 of 1%	10°	.1

FRICTION TESTS

The instrument may be tested for mechanical friction at this point by connecting it to a suitable source of power and deflecting it at least 25% of full scale, then reducing the deflecting current to zero. No instrument should be accepted for use if it has any appreciable friction.

CALIBRATION CHECK

No actual calibration check should be made until the instrument has become thoroughly temperature saturated at ambient room temperatures for at least four hours. Allow it to reach room temperature. SENSITIVE RESEARCH calibrates all instruments at exactly 25° C.

Make sure you are on the right range for your power supply. If in doubt set the range switch, if any, on the instrument on its highest range. This will prevent overloading of the instrument when starting any electrical tests. If only a slight pointer deflection results when power is applied, then successively switch the instrument range selector DOWN until a suitable reading is obtained. Bring the pointer up to full scale and open the instrument circuit. A special precaution should be taken by the user of thermocouple instruments: AVOID opening the primary circuit of a transformer whose secondary circuit is being measured by thermocouple instruments. The reason for this is that the transformer as an energy storing device may, under certain conditions, DISCHARGE its energy into the secondary circuit, thereby overloading the thermocouple instrument. (Overloads of 1000% are quite possible in transformer circuits.)

THERMOCOUPLE INSTRUMENT CIRCUITS

The above standardized thermocouple Millivoltmeter is used in our thermocouple instrument. This Millivoltmeter becomes a known load across the D.C. output of a thermocouple which lends itself to the accurate calculation of our own design temperature compensation circuit.

AUTOMATIC TEMPERATURE COMPENSATION

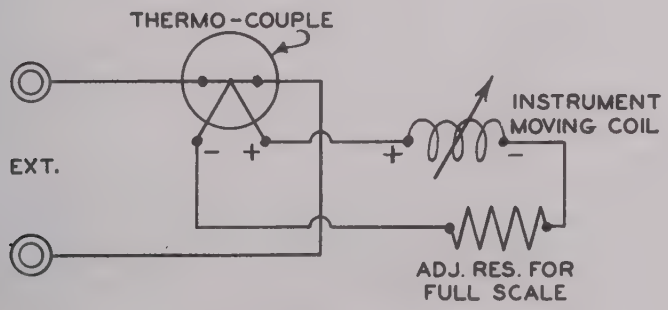
By the use of an automatic temperature compensation network, the usual HIGH temperature coefficient of a thermocouple instrument is reduced to a value so low, that NO temperature correction need be applied when the ambient termperature varies from 20°C. to 30°C. Outside of this range of temperature, there is a very small temperature coefficient. The proper temperature correction information is supplied with each instrument on its data card in the instrument cover.

SINGLE RANGE CURRENT INSTRUMENTS

For current below 1 ampere (1000 milliamperes) the vacuum thermocouple is mounted inside the instrument. When an instrument is fitted with our replacement feature, the thermocouple can be readily removed without disturbing the instrument proper. On instruments that do not have this feature, the instrument seal must be broken and the bakelite panel removed to obtain access to the thermocouple.

A single range thermocouple instrument can be used on D.C. and A.C. up to about 1 megacycle.

A typical circuit of which is shown below.

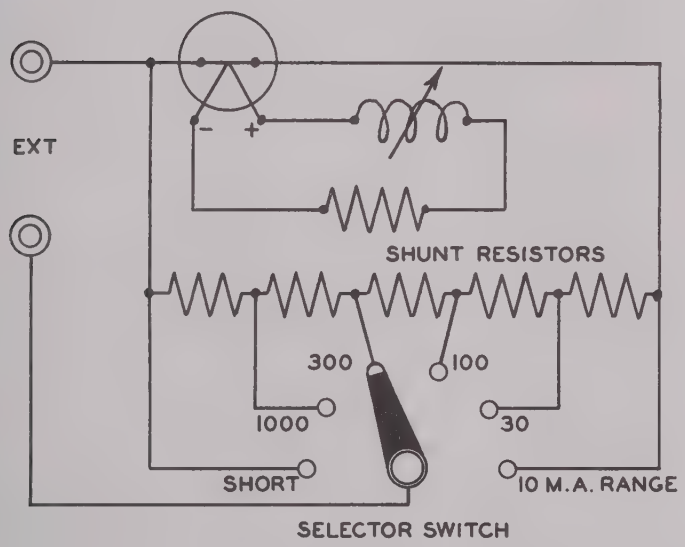


SINGLE RANGE FOR D.C. & A.C.
OF ALL FREQUENCIES

By the proper selection of our vacuum thermocouples, ranges from 1 milliampere, full scale to 1000 milliamperes, full scale are readily obtained. Using our air couples (Model "XT" Instruments) currents up to 100 amperes, full scale are available.

MULTIRANGE CURRENT INSTRUMENTS

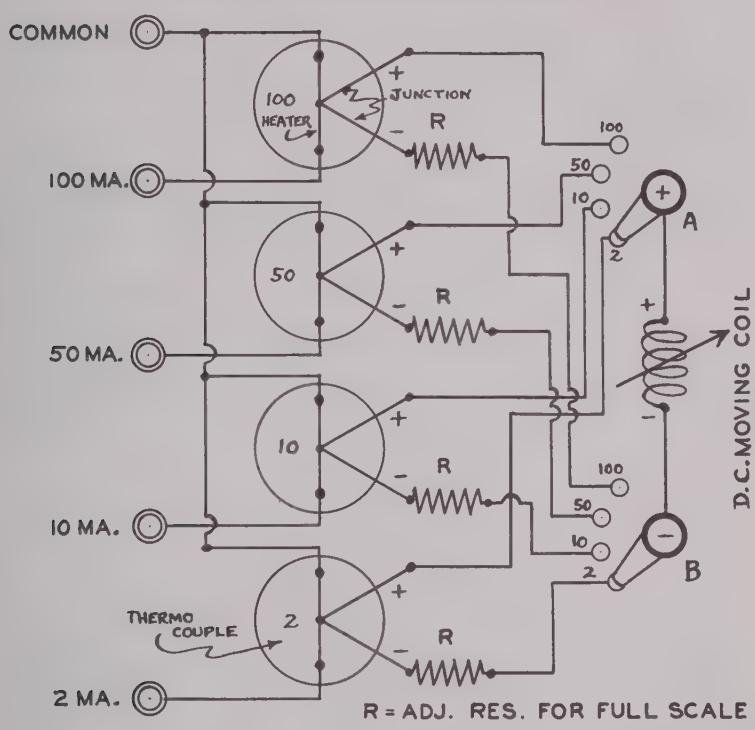
When multiranges are desired, they are usually obtained in the low audio frequencies (up to 20,000 cycles) by shunting the heater circuit of the thermocouple. See circuit below.



The values of the separate resistances of this universal shunt (often called Aryton-Mather) are readily calculated. To prevent self heating of the instrument, usually for good instrument practice heavy current shunts and high voltage range resistances are mounted in ventilated compartments attached to the instrument.

When multiranges are required for measurement at frequencies above 20 KC., then a SEPARATE thermocouple must be used for EACH range. A maximum of four (4) ranges using four (4) thermocouples is available. (A typical diagram of a four range instrument, our Model "RF", is shown below.)

MODEL "RF" MILLIAMMETER



SWITCHES A & B OPERATED IN CONJUNCTION WITH BINDING POSTS

MULTIRANGE THERMOCOUPLE VOLTMETERS

Starting with the basic single range thermocouple CURRENT CIRCUIT, it is quite easy to create a thermocouple voltmeter of single or multiranges.

Knowing the resistance of the heater circuit of a thermocouple and using OHM'S LAW, multiranges of voltage are calculated.

EXAMPLE:

We have a 10 milliampere thermocouple with a heater resistance of 40 ohms. We wish to construct a 0 - 2-10-50-100 Volt instrument using OHM'S LAW.

(1st Range) $R = \frac{E}{I} = \frac{2 \text{ volts}}{.01 \text{ amps}} = 200 \text{ Ohms}$
(10 M/A Heater Current)

Resistance of 1st range at 10 m/a must be 200 ohms. 200 - 40 ohms heater resistance = 160 ohms. Therefore, a 160 ohm resistance must be used in series with the heater of the thermocouple so that an external impressed voltage of 2 volts will cause a current flow of 10 m /a, or a full scale reading of the instrument. This full scale reading, 10 m/a, will be marked 2 volts on the scale.

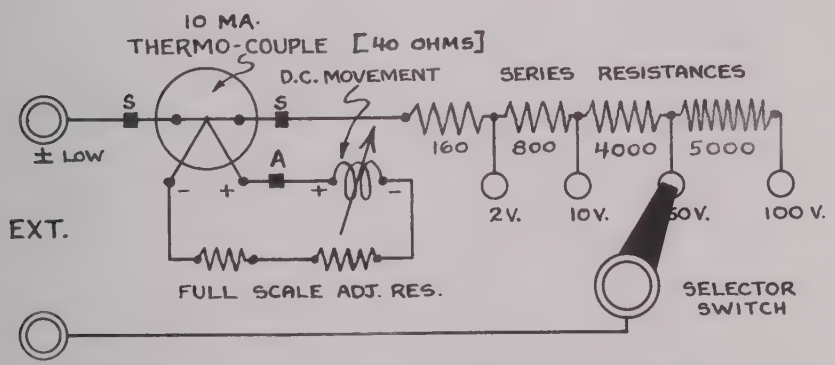
(2nd Range) $R = \frac{E}{I} = \frac{10}{.01} =$ 1000 Ohms $\frac{1000}{-200}$ (Res. of 1st Range)

800 Ohms

Therefore, a resistance of 800 must be connected in series with the 160 Ohms so that a complete 1000 Ohm circuit will exist.

The 3rd and 4th ranges are calculated in like manner.

The instrument circuit when completed is shown below. Its resistance is 100 Ohms per volt. (Full scale current is 10 Milliamperes.)



MULTIRANGE VOLTMETER CIRCUIT

The symbol "A" is the position occupied in the junction and moving coil circuit of our automatic temperature compensation network.

The two symbols, "S" and "S", show the circuit positions of our "SAFETY KEY" wiring which is installed on almost all our thermal instruments.

THERMOCOUPLE OVERLOADING

All vacuum thermo-couple instruments, irrespective of their maker, will not stand overloads over 100% without damage to the thermo-couple, unless protected.

A special precaution which should be taken by the user of thermo-couple instruments is to avoid opening the primary circuit of a transformer whose secondary circuit is being measured by thermo-couple instruments. The reason for this is, that the transformer as an energy storing device, may, under certain conditions, discharge its energy into the secondary circuit, thereby overloading the thermo-couple instruments. This danger can be eliminated by either disconnecting the instrument from the secondary circuit before opening the primary circuit or by including a Variac in the primary circuit so that the excitation of the primary may be reduced to zero before switching off.

OPERATING INSTRUCTIONS

A.C.-D.C. *"SELF CHECKING" VOLT-AMP-MILLIAMMETER

MODEL THACH No. DATE

COMBINATION 2X
15/30/75/150/300/750 m.a./1.5/3 Amperes
1.5/3/7.5/15/30/75/150/300/750 Volts

Accuracy .2 of 1%
On D.C. and A.C. Up to 4000 Cycles
Accuracy 1% on Volts and Current at 15 K.C.

PRELIMINARY PROCEDURE

After removing the instrument dust cover, check and adjust if necessary the mechanical zeros of the instrument and its galvanometer. This is accomplished by slotted zero screws located on the panel near their movement's center.

If the instrument has not been used for some time it is considered good instrument practice to rotate all rheostats and selector switches a few times, so the contacts could "self clean" themselves.

SELF CHECKING PROCEDURE

When Self-Checking, from the standpoint of good instrument practice it is considered advisable to disconnect any external voltage circuit from the instrument binding posts.

The instructions below are engraved on the panel just above the galvanometer scale window.

SELF CHECKING PROCEDURE

1. PUSH CHECK SWITCH TO RIGHT
2. TURN COARSE & FINE CONTROLS UNTIL GALVANOMETER READS ZERO
3. KEEP CHECK SWITCH TO RIGHT
4. TURN INSTRUMENT MICRO-CONTROL UNTIL THE STANDARD INSTRUMENT READS EXACTLY FULL SCALE
5. RECHECK GALVANOMETER WHICH SHOULD STILL BE BALANCED
6. PUSH CHECK SWITCH TO LEFT TO "READ"

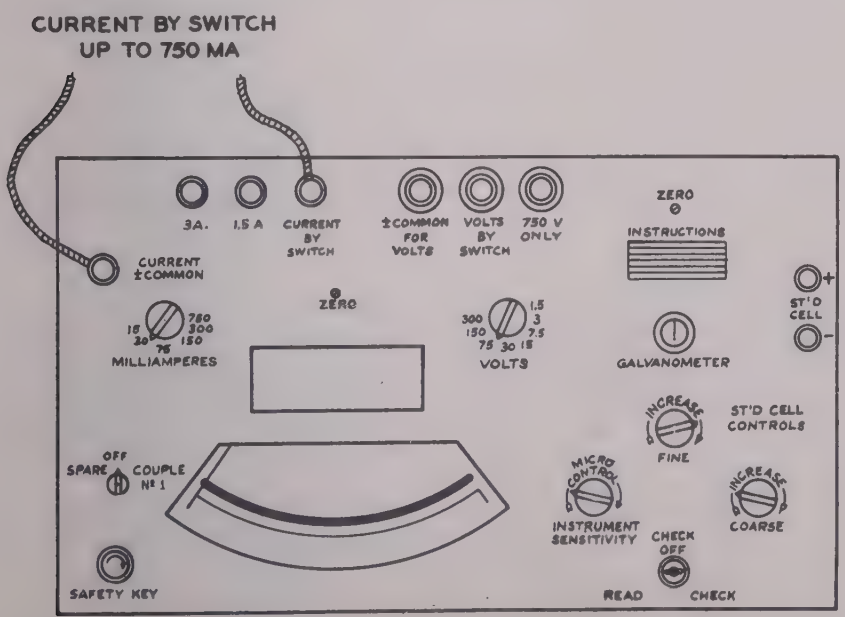
The standard model THACH contains one internal thermocouple. The DeLuxe model contains two internal thermocouples. Either thermocouple can be used by switching from one to the other by a small selector switch located on the left side of the panel. This switch is marked "No. 1" and "Spare Thermocouple." Readings should be taken on the scale marked "No.1" when using the "No.1" thermocouple and on the scale marked "SPARE" when using the "SPARE" thermocouple.

When the "check-transit-read" switch is moved to its "check" position it sends a STANDARD CURRENT through the instrument WHEN the galvanometer is balanced.

This is done by adjusting the fine and coarse standard cell rheostats. The instrument is then certified by adjusting the INSTRUMENT MICRO CONTROL knob until the instrument pointer reads EXACTLY full scale. Keep the standard cell circuit balanced. This is evidenced by a ZERO deflection of the galvanometer. This procedure is very simple and only takes a few moments. After certifying, turn the "check" switch to its "read" position. The instrument is then ready for use. It is suggested that you "self check" the instrument a few times before actually using it for the first time. When self checking, the SAFETY KEY should be LOCKED in the "depressed" position. The safety shunt is now NOT operating. Then, before actual use, UNLOCK the safety key and proceed in the manner and method as described in these instructions.

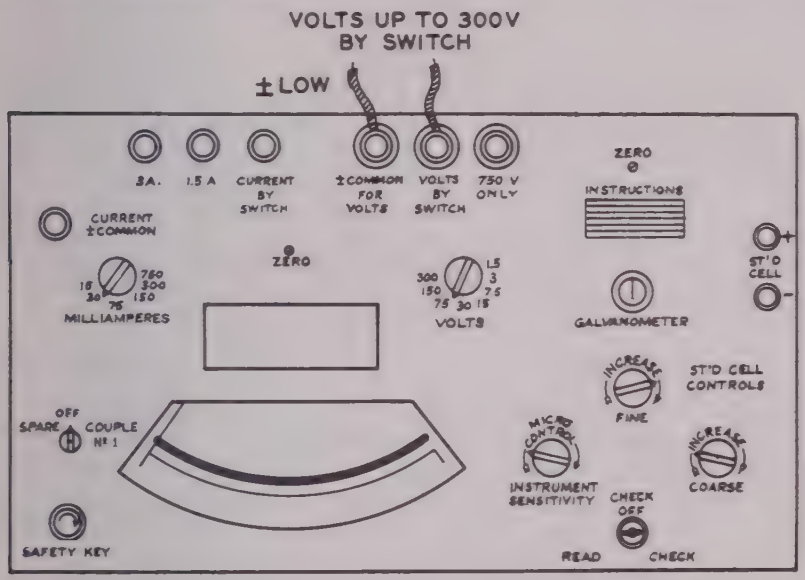
CURRENT MEASUREMENTS UP TO 750 MILLIAMPERES

Use the "COMMON FOR CURRENT" binding post and the "CURRENT BY SWITCH" post for measurements up to 750 milliamperes. See drawing below.



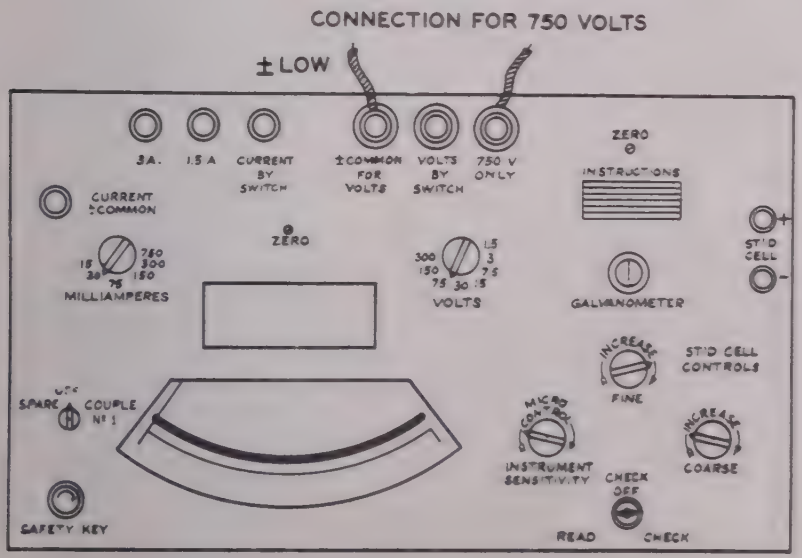
VOLTAGE MEASUREMENTS UP TO 300 VOLTS

Connect one lead to the "±COMMON FOR VOLTS" binding post and the other lead, if the voltage is below 300 volts, to the "VOLTS BY SWITCH" binding post. See drawing below.



VOLTAGE MEASUREMENTS UP TO 750 VOLTS

Connect one lead to the "±COMMON FOR VOLTS" binding post and the other lead to the 750 volt post. See drawing below.



OVERLOAD PROTECTION

On the left side of panel is a "safety key" button. When this is UP, (not depressed), it places a compensated resistance safety shunt across the thermocouple being used. You will notice a red line marked "SAFETY" on the instrument scale which is drawn on the first calibrated point above the zero line. Now this is IMPORTANT. If, when the safety button is UP, the instrument pointer deflects ABOVE this red line, it indicates that the instrument is being OVERLOADED. (When the safety button is UP, the thermocouple will stand 1000% overload.) Either externally reduce the voltage or current or select a higher range until the pointer reads BELOW the red line. Then depress, or "turn to lock" the safety key and the instrument is ready for use. When the safety button is depressed, the pointer will deflect up scale to the value of the voltage or current. The operation of the "safety button" will not affect any external circuit.

(OVERLOAD ON THE 500, 750, AND 1000 VOLT RANGES IS 100% IF THE SAFETY KEY IS DEPRESSED)

STANDARD CELL

The standard cell may be checked by measuring its voltage by means of a potentiometer connected to the red "Standard Cell" binding posts. NEVER use a voltmeter of any sort. If should read within ±.05% at 25°C. of volts. If the standard cell voltage does not fall within these accuracy limits, it should be replaced. See drawing #

Replacement standard cells are available from us encased with a typical 4 prong vacuum tube base. To replace remove bakelite cover on bottom of case and simply pull out old cell and push in the new one.

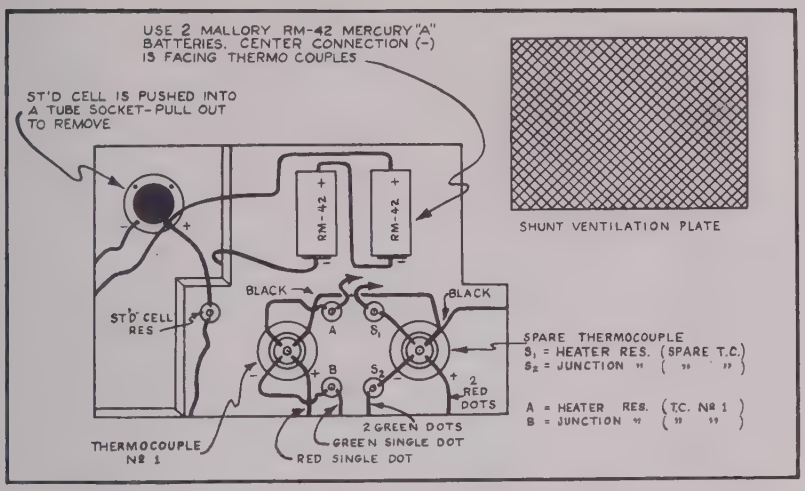
BATTERY REPLACEMENT

These should be replaced whenever the standard cell rheostat controls are required to be near their "maximum increase" positions for full scale instrument deflection when self checking. We use two (2) Mallory Mercury "A" batteries #RM-42. They are held in position by suitable clips. Be sure that their center contact (-) negative faces the thermocouples (see drawing on page).

THERMOCOUPLE REPLACEMENT

Replacement thermocouples are only supplied by us when the instrument was originally purchased or at a time when it was in our possession. To replace a thermocouple it will be necessary to unsolder and remove the old thermocouple with its two (2) adjusted resistances. The new thermocouple as obtained from us has two calibrated resistances permanently soldered to each thermocouple. This leaves 4 leads to be connected into the circuit. The drawing on page shows our DeLuxe model with 2 thermocouples. The standard model has only one thermocouple but the method below is the same. The leads are marked with colored dots.

1. Black lead from thermocouple itself to holder lug as shown.


USE 2 MALLORY RM-42 MERCURY "A" BATTERIES. CENTER CONNECTION (-) IS FACING THERMO COUPLES
ST'D CELL IS PUSHED INTO A TUBE SOCKET - PULL OUT TO REMOVE
RM-42
RM-42
SHUNT VENTILATION PLATE
BLACK
BLACK
ST'D CELL RES
A
S_1
B
S_2
2 RED DOTS
SPARE THERMOCOUPLE
S_1 = HEATER RES. (SPARE T.C.)
S_2 = JUNCTION " (" ")
A = HEATER RES. (T.C. Nº 1)
B = JUNCTION " (" ")
2 GREEN DOTS
GREEN SINGLE DOT
RED SINGLE DOT
THERMOCOUPLE Nº 1

2. Lead from heater resistance to same soldered joint as the removed thermocouple lead (identified as resistance "SI" or "A" which has a black lead going to the thermocouple itself).

3. Red lead from thermocouple itself connected to black lead marked with red dot or red dots.

4. Lead from junction resistance "S2" or "B" identified as resistance which has a green lead going directly to thermocouple and it is connected to the black lead marked with green dot or dots.

ACCURACY CHECK

Due to its high accuracy, this instrument should be checked on D.C. only against (ABS) absolute standard resistances and shunts using an ABS certified precision potentiometer.

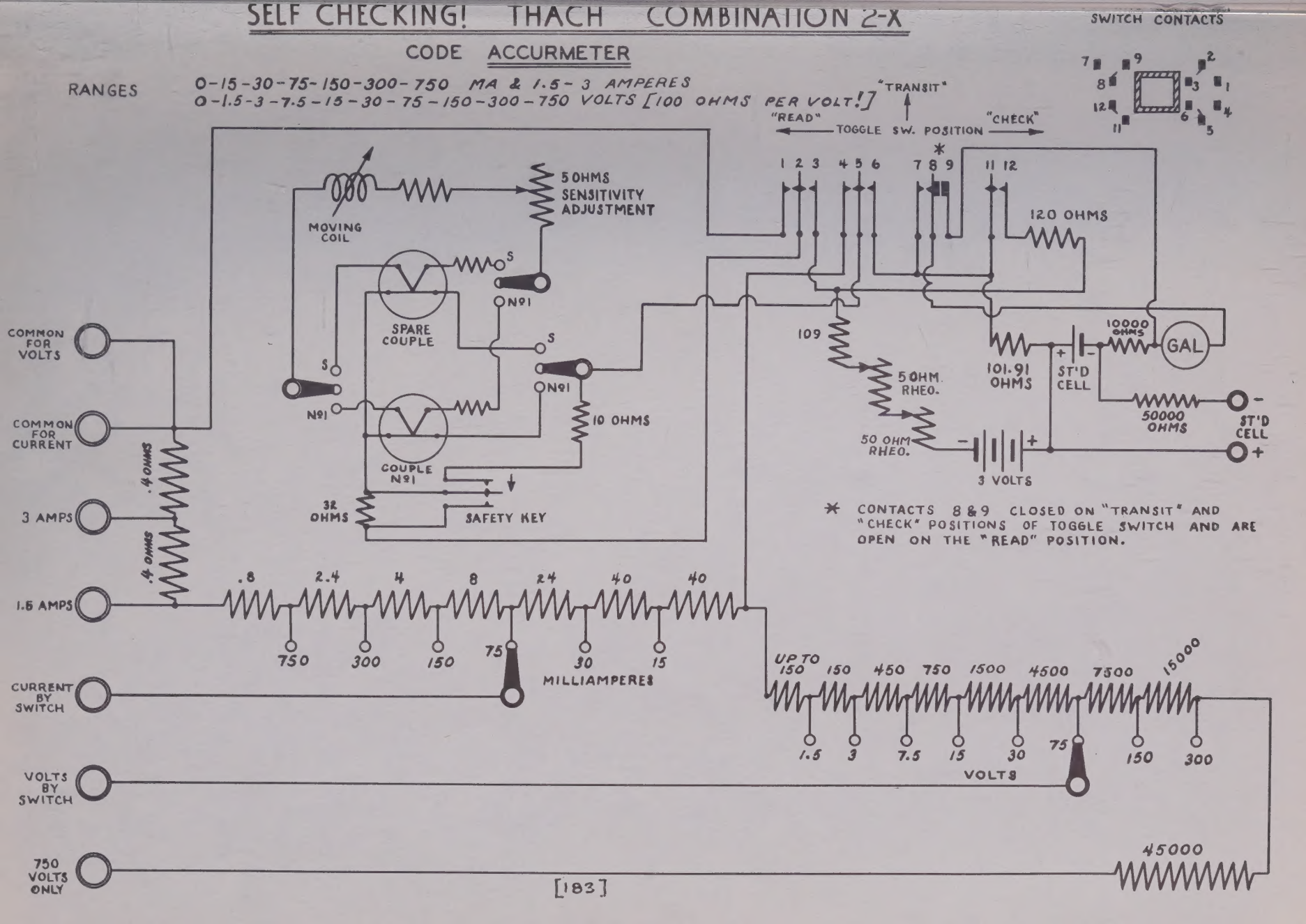
IMPORTANT

When shipping the instrument, place the "check-transit-read" switch on its "transit" position to prevent damage to the galvanometer suspension.

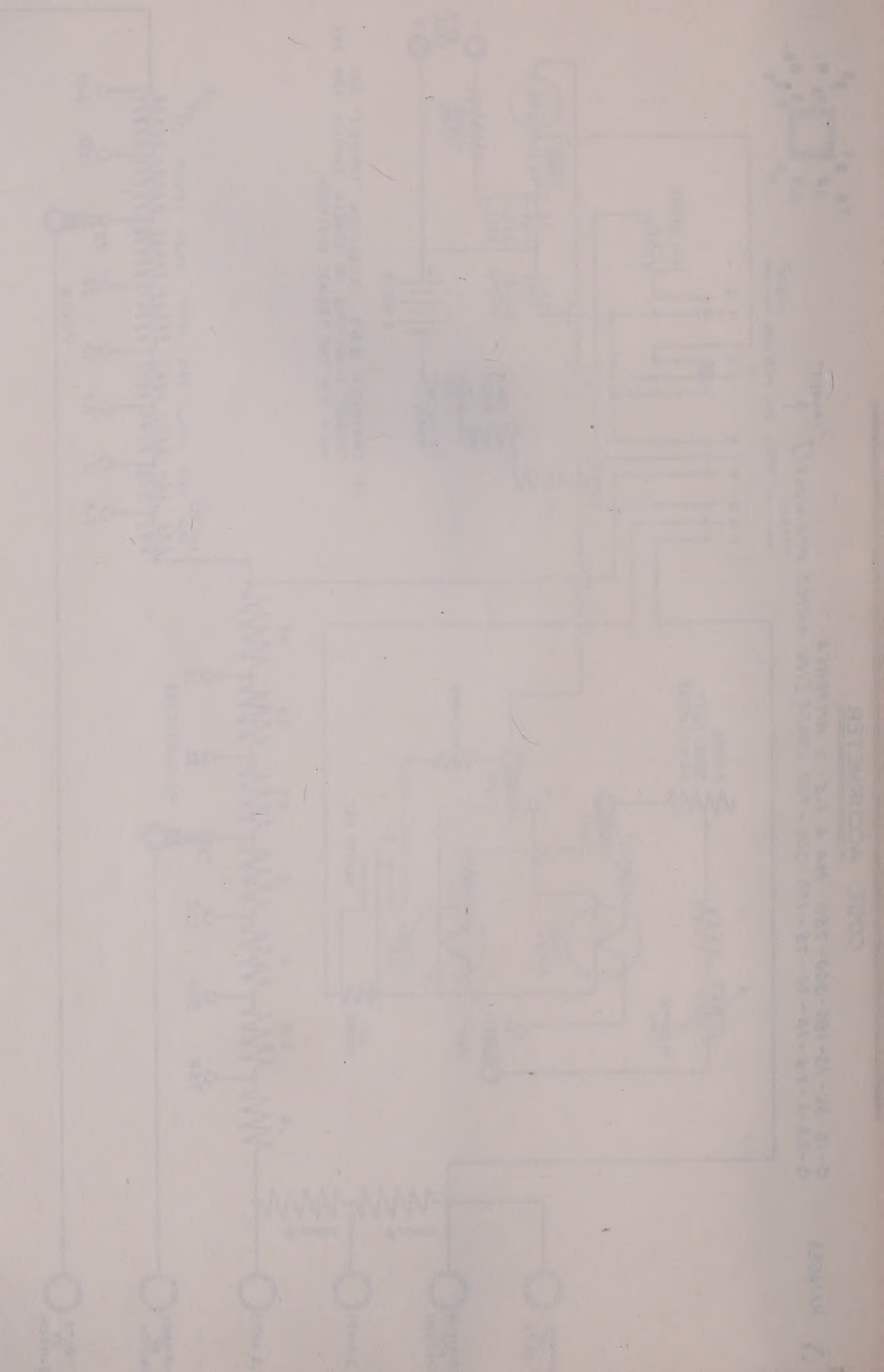
SELF CHECKING! THACH COMBINATION 2-X

CODE ACCURMETER

RANGES 0-15-30-75-150-300-750 MA & 1.5-3 AMPERES
0-1.5-3-7.5-15-30-75-150-300-750 VOLTS [100 OHMS PER VOLT!]



* CONTACTS 8 & 9 CLOSED ON "TRANSIT" AND "CHECK" POSITIONS OF TOGGLE SWITCH AND ARE OPEN ON THE "READ" POSITION.



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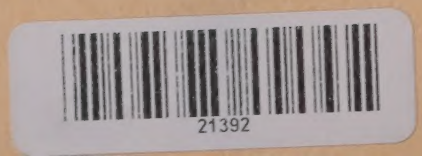
Amtile

IVORY


21392